

**Systems Thinking Assessment  
of  
Multidiscipline Teams  
at  
NASA Langley Research Center**

***with Implications for their Formation, Management, and Operation***

***(Internal Dynamics)***

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# Outline

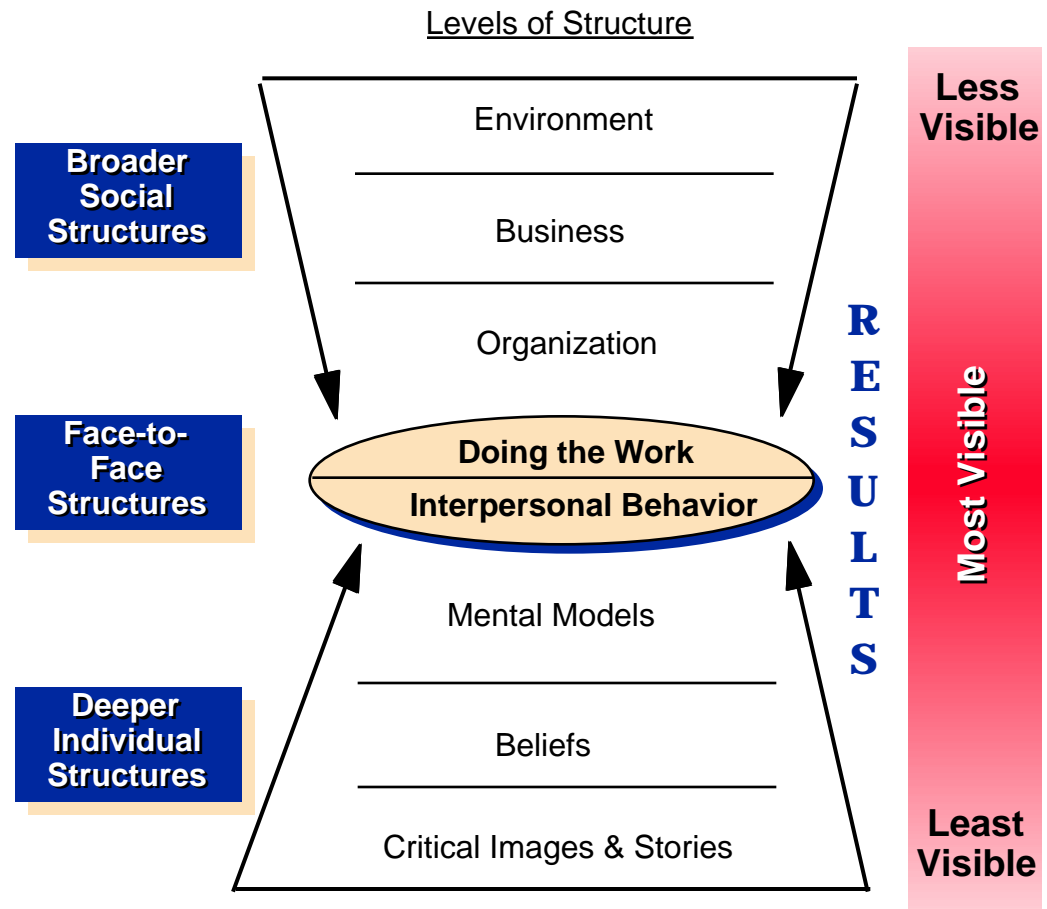
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# Key Objectives

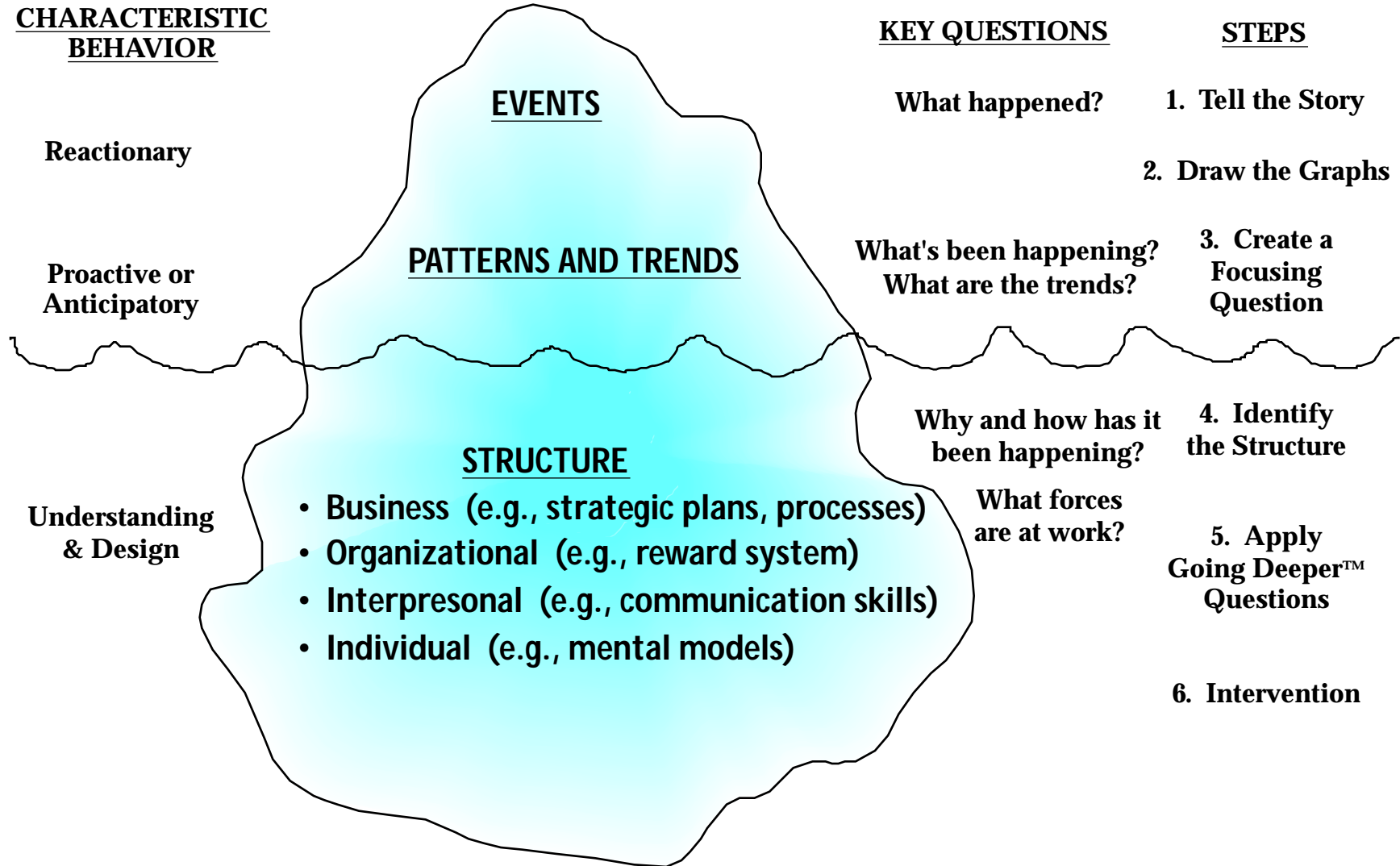
- **Identify barriers to success for multidiscipline research teams at NASA Langley.**
- **Develop recommendations that will help multidiscipline teams to be more effective.**
- *Develop a Langley-based application of systems thinking to a real, practical, and significant issue.*
- *Document the effort in a case study to be available for training and a reference for future efforts.*

# Systems Thinking Overview

- A discipline for seeing structures (the patterns and connections) underlying seemingly diverse personal, organizational and societal issues.
- Helps us understand and describe complex issues.
- Points to higher leverage solutions to problems.
- The harder you push, the harder the system pushes back.
- The easy way out usually leads back in.
- Small changes can produce big results -- but the areas of highest leverage are often the least obvious.
- There is no blame.



# Systems Thinking Framework



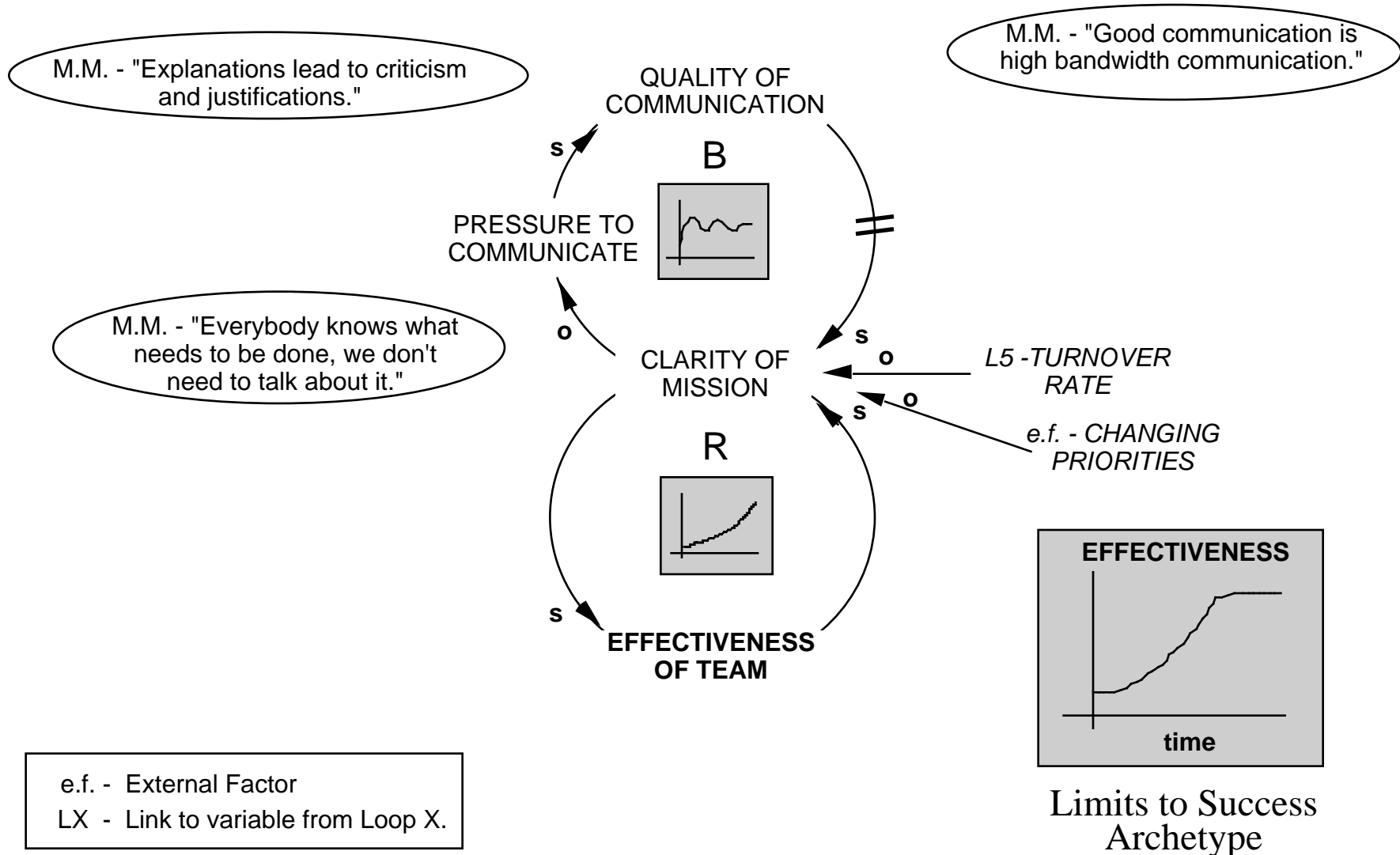
# **Our Approach**

- **Select recent multidiscipline teams with a “rich” history**
  - **Airframe Noise Team (ANT)**
  - **Longitudinal Controls Alternatives Project (LCAP)**
  - **MDO Detailed Planning Team**
- **Interview cross-section of team members to determine influential factors affecting success**
- **Identify key variables and structural elements affecting team performance**
- **Distinguish between internal and external dynamics**
- **Seek causal relationships between key variables that supported the outcomes**
- **Diagram the causal links and identify archetypical structures that suggest potential interventions**
- **Identify high-leverage interventions to achieve desired results (long-lasting, self-sustaining, involving choice)**

# Key Variables and Factors

- The variable central to the key issue and to most of the causal links is *Team Effectiveness*
- Represents a variety of *desired characteristics of highly successful teams*
  - ability to meet milestones and deadlines
  - high quality products
  - long-term impact
  - exceed expectations (sponsor, organization, customers)
  - effective communication
  - high productivity and efficiency
  - . . .

# #1 - Clarity of Mission Diagram





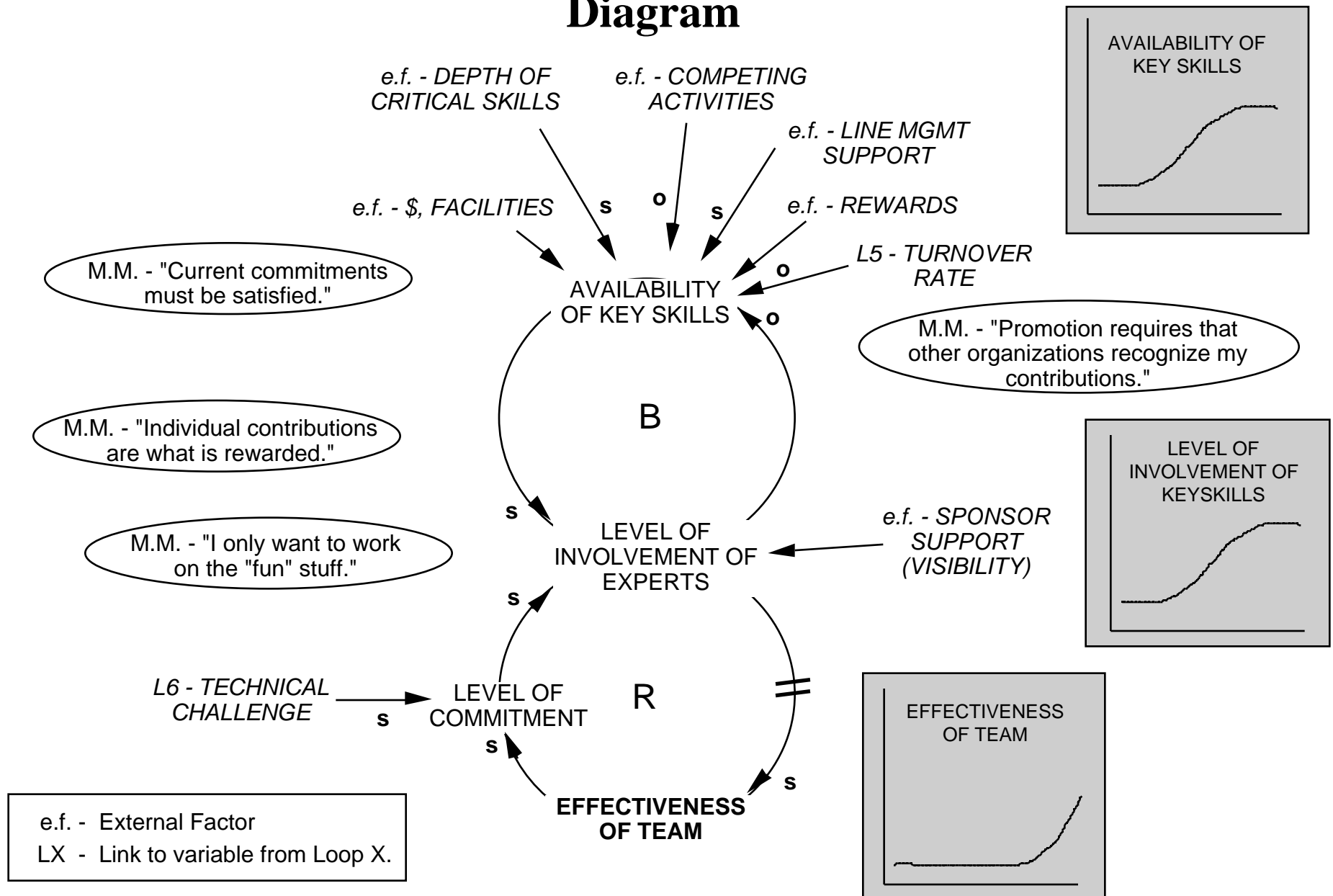
# **#1 - Clarity of Mission**

## **Key Structures and Interventions**

- **Key Structures**
  - a clear mission reduces pressure for communication
  - reduced communication erodes shared vision
  - everyone knows what needs to be done, we don't need to talk
  - open communication with significant inquiry can be seen as prying
  - high bandwidth is sometimes equated with good communication
  
- **Potential Interventions**
  - weaken link between pressure to communicate and quality of communication (keep the pressure on)
    - develop team processes to maintain focus on priorities and mission
    - adapt to changing needs of information content
    - monitor quality and quantity of communication
    - avoid trap of equating quality with quantity and/or frequency

# #2 - Involvement of Key Experts

## Diagram

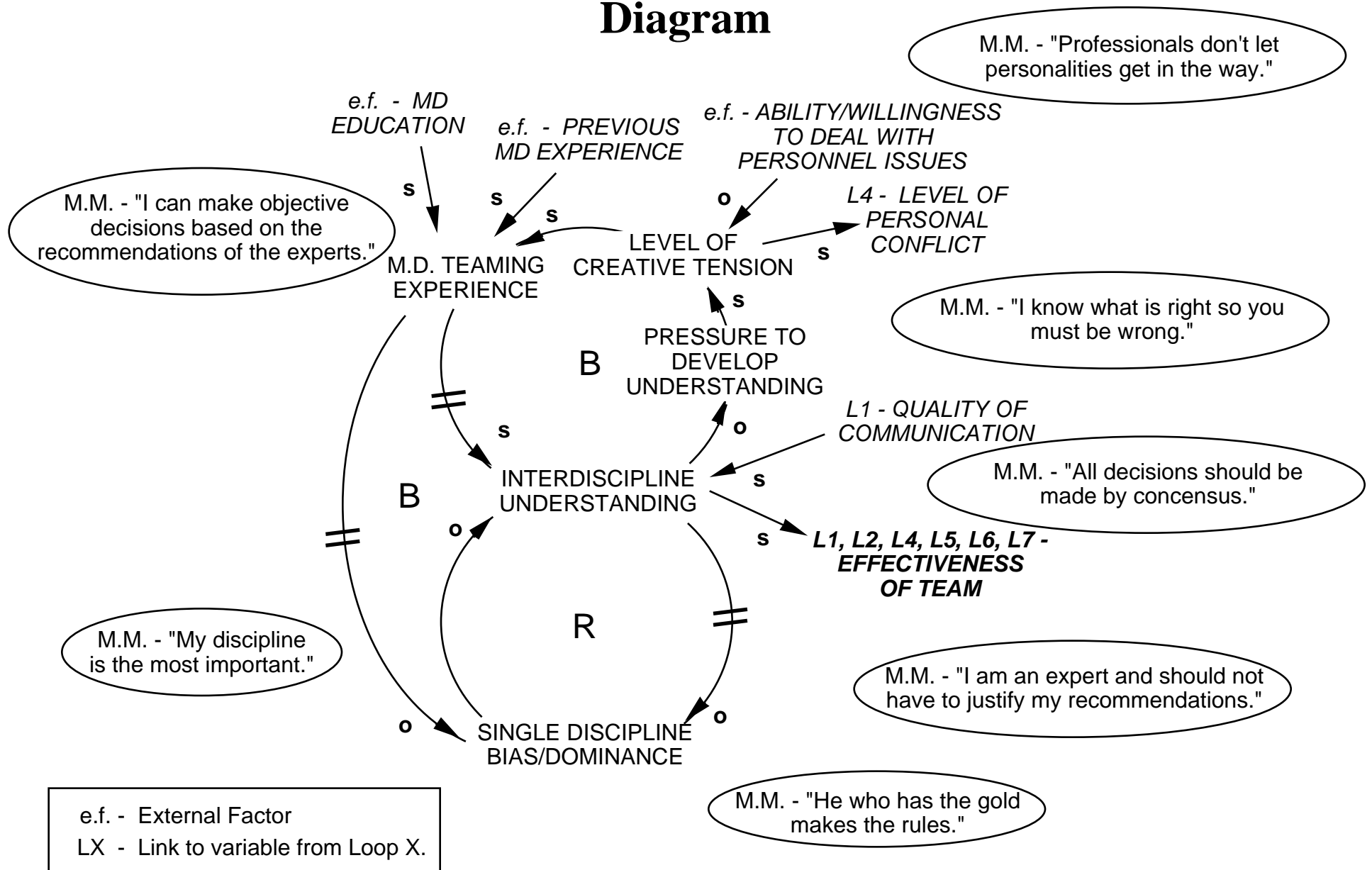


# **#2 - Involvement of Key Experts**

## **Key Structures and Interventions**

- **Key Structures**
  - improved effectiveness leads to more commitment and involvement of key experts
  - dependence on scarce resources puts pressure on key experts
  - fidelity to previous commitments
  - limited depth in certain key skills
  - individual contributions are what is recognized and rewarded
- **Potential Interventions**
  - increase availability of key skills
    - maintain and develop expertise in key areas
    - sacrifice short-term effectiveness for long-term benefit of enhanced skills and expertise (“on the job training”)
  - enhance commitment of those with key skills
    - appeal to benefits of “stepping up”
    - strengthen “benefits” of team participation

# #3 - Multidisciplinary Teaming Experience Diagram



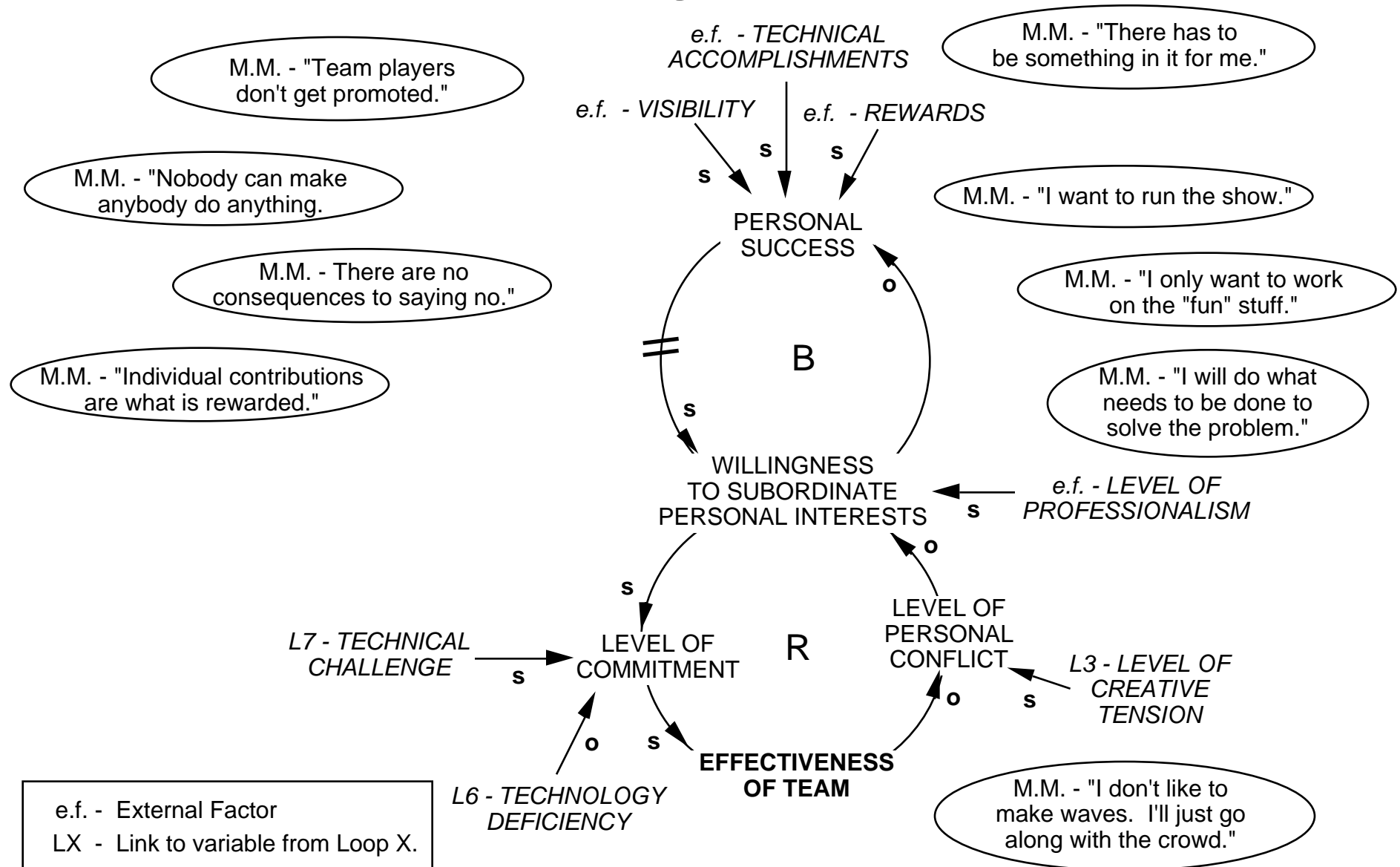
# **#3 - Multidisciplinary Teaming Experience**

## **Key Structures and Interventions**

- **Key Structures**
  - creative tension is required to foster interdiscipline understanding
  - as understanding develops the pressure comes off
  - organizational bias toward single disciplines reinforces biases
  - tension can manifest itself as personal conflicts
- **Potential Interventions**
  - develop opportunities to enhance cross-discipline understanding and appreciation
    - increased number of multidiscipline efforts
    - expectation for skills development and educational opportunities
  - develop infrastructure to reduce tendency for single discipline focus
    - organizational and funding structures (e.g., ASPO)
    - program goals and objectives (e.g., 3 Pillars)
  - anticipate and deal promptly with conflicts that arise when working across organizations

# #4 - Willingness to be a Team Player

## Diagram



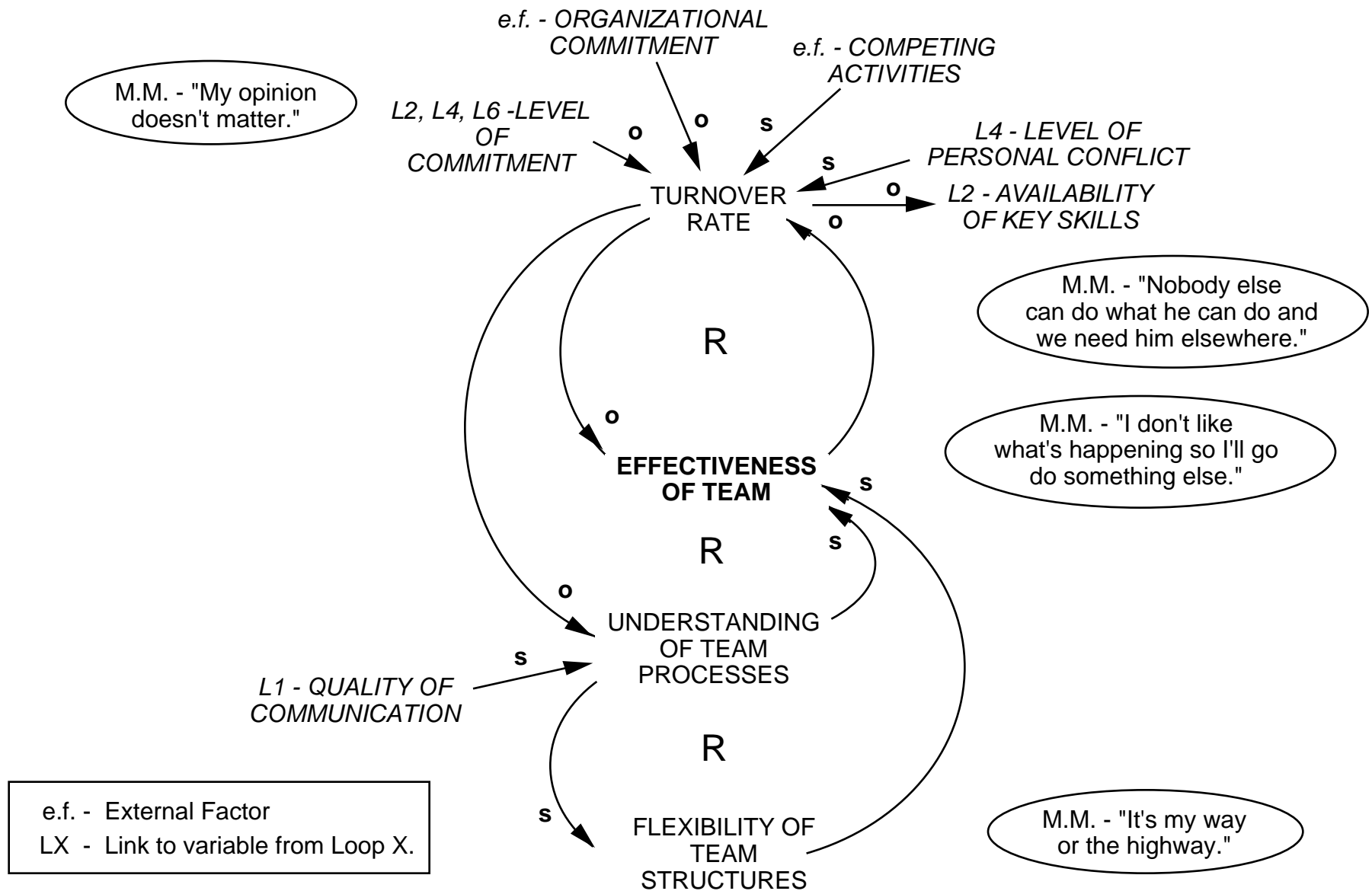
# **#4 - Willingness to be a Team Player**

## **Key Structures and Interventions**

- **Key Structures**
  - multidisciplinary research often requires willingness to subordinate to team objectives
  - personal success has generally been associated with sophisticated discipline expertise and individual accomplishments
- **Potential Interventions**
  - link personal success to team success and team participation
    - strengthen structures that support desire to do multidiscipline work
      - rewards, visibility, technical challenges (goals and objectives)
    - emphasize personal benefits of team efforts
      - collaborative synergy, personal satisfaction, new knowledge / capability
    - weaken structures that support single discipline work

# #5 - Effectiveness of Team Processes

## Diagram





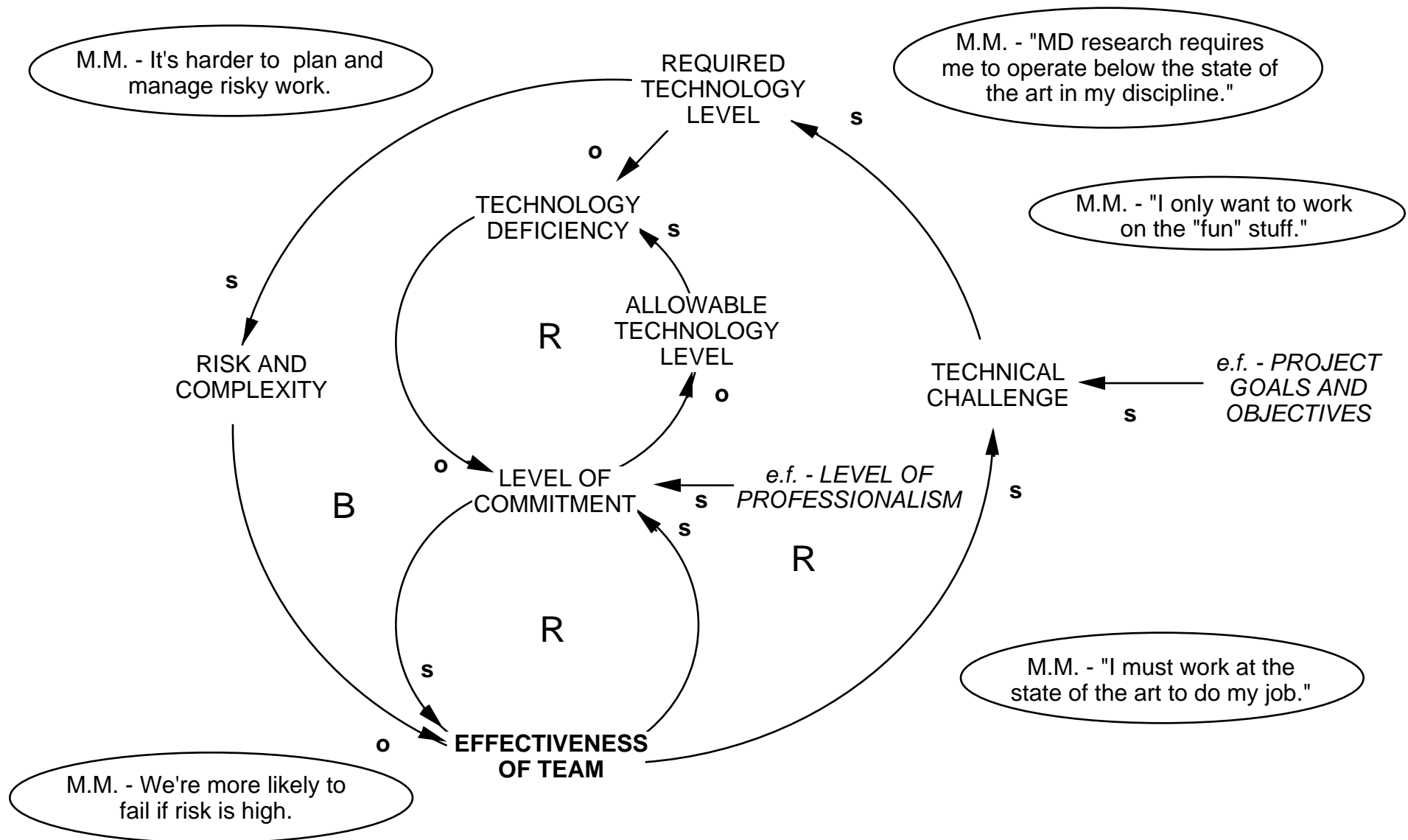
# **#5 - Effectiveness of Team Processes**

## **Key Structures and Interventions**

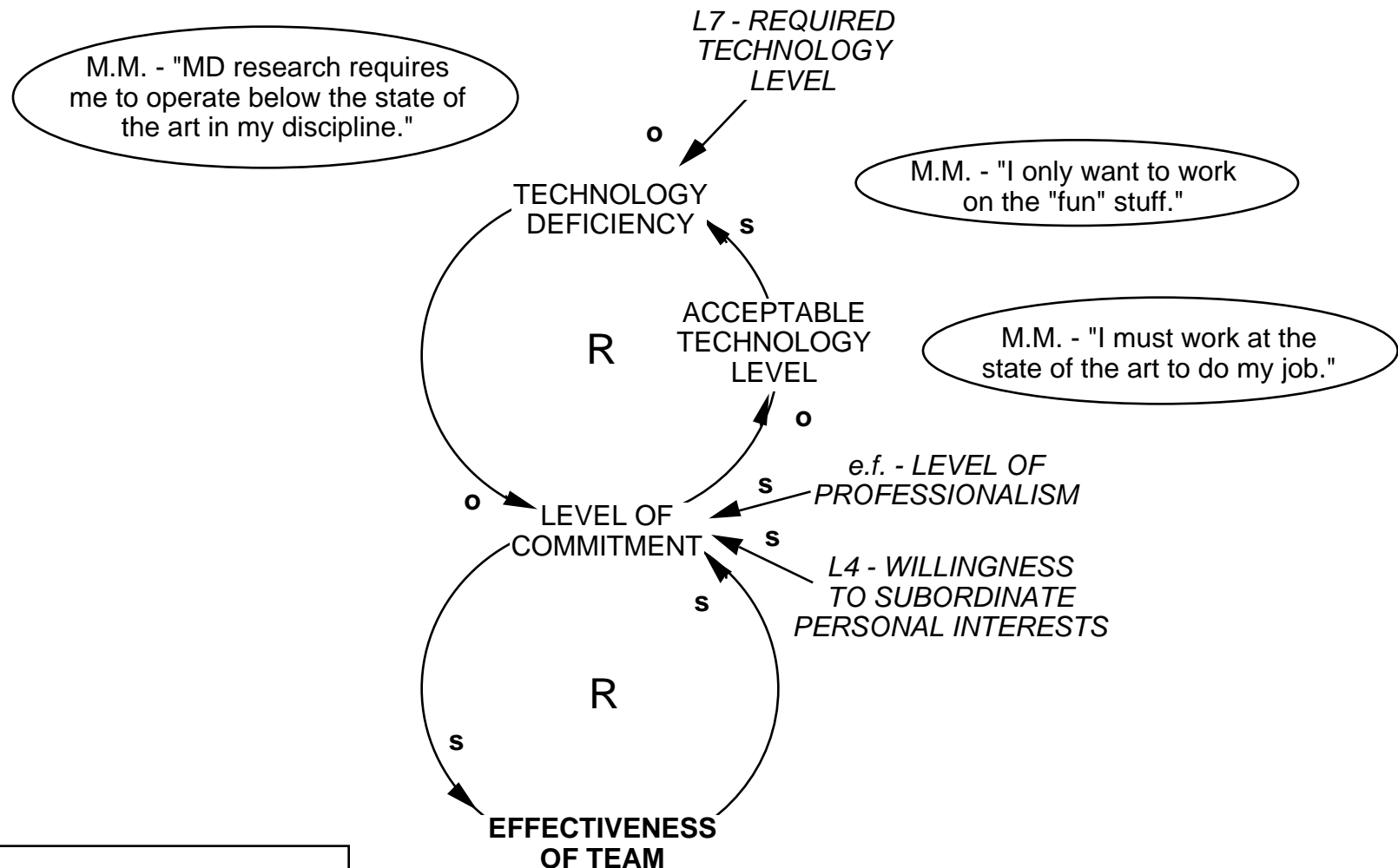
- **Key Structures**
  - effectiveness strongly dependent on turnover (loss is immediate, recovery is slow)
    - lost technical capability
    - backtracking, bringing new members up to speed
  - external factors play a major role (uncertainty, lack of control)
- **Potential Interventions**
  - minimize turnover in areas where expertise is key or scarce
    - match team members with project requirements
    - maintain sponsor support
  - anticipate and prepare for turnover in key areas
    - maintain flexible and adaptive team management processes to respond to changing priorities and concerns
    - utilize benchmarks and guidelines for effective research team management methods (e.g., standards, common practices)

# #6 + #7 - Balancing the Level of Technology

## Diagram



# #6 - Working Below the State of the Art Diagram



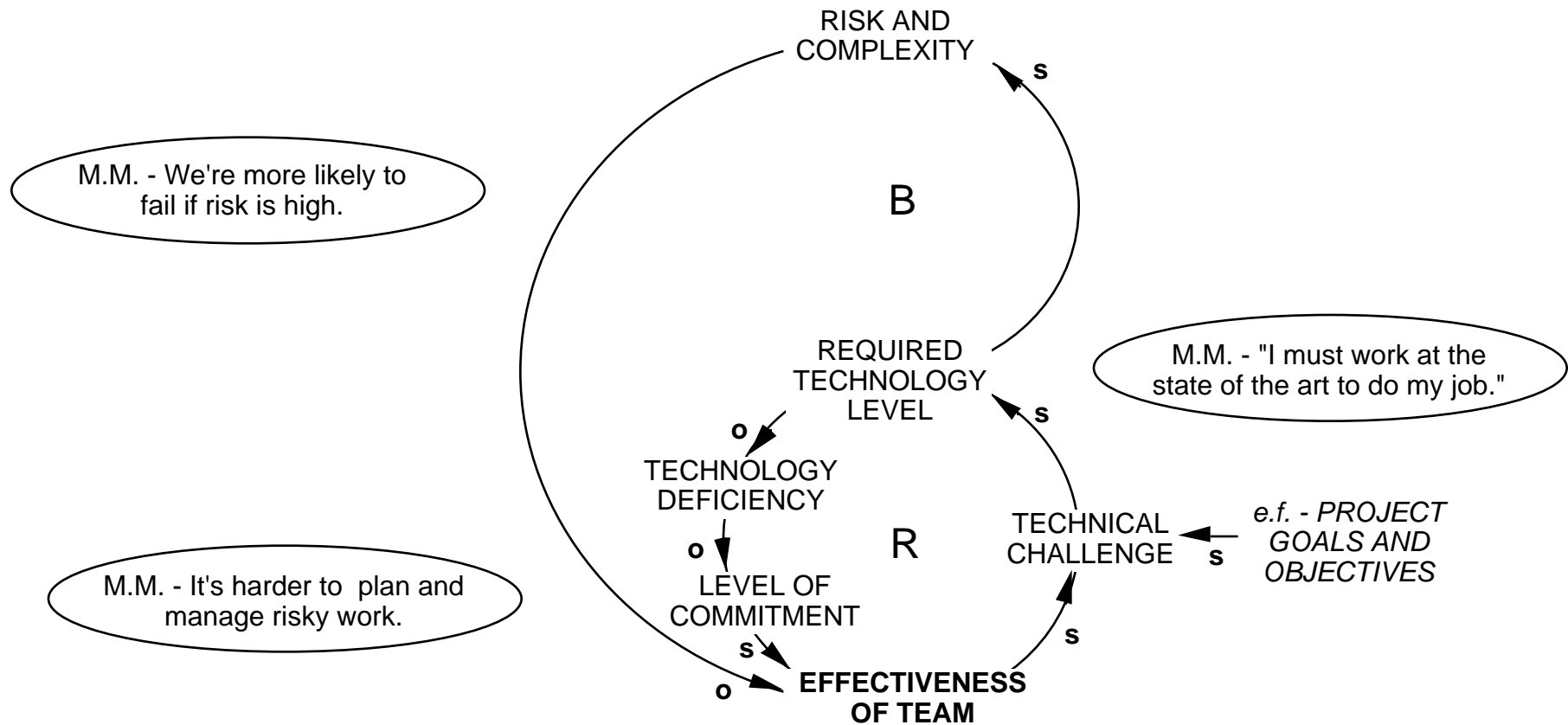
e.f. - External Factor  
LX - Link to variable from Loop X.

# **#6 - Working Below the State of the Art**

## **Key Structures and Interventions**

- **Key Structures**
  - certain level of technology is required to achieve the objectives
  - certain level of technical sophistication is needed to interest and satisfy discipline researchers
  - difference between the two levels leads to erosion of commitment which exacerbates the problem (vicious circle)
- **Potential Interventions**
  - eliminate the technology deficiency
    - alter goals and objectives to increase the level of technology required
    - decrease the level of technical sophistication acceptable to individual researchers
  - enhance commitment by alternate means to deal with existing deficiency
  - select team members with tolerance for lower technical sophistication (match members with technologies)

# #7 - Pushing the State of the Art Diagram



e.f. - External Factor

LX - Link to variable from Loop X.

# **#7 - Pushing the State of the Art**

## **Key Structures and Interventions**

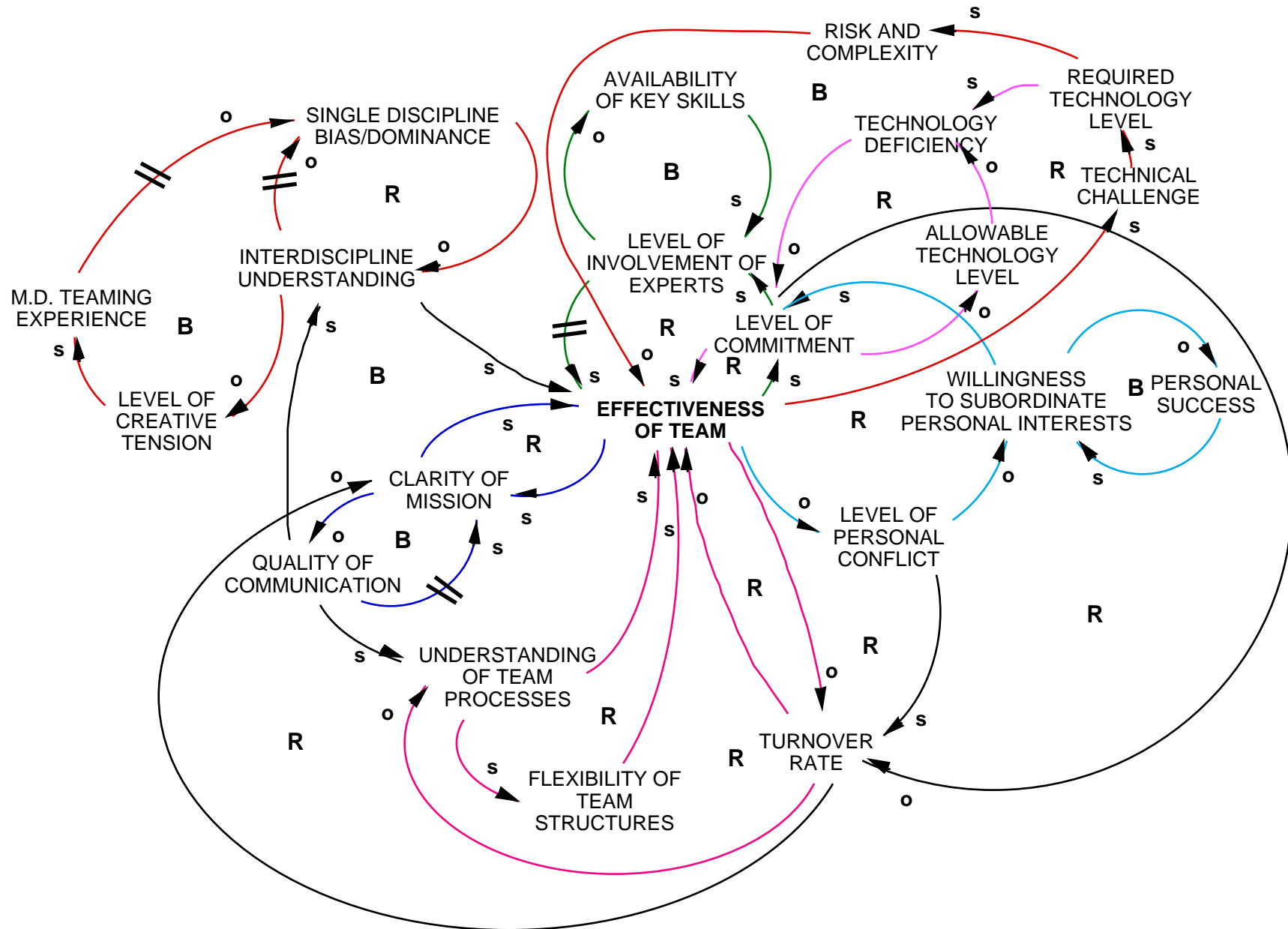
- **Key Structures**

- higher levels of technical challenge lead to the need for more sophisticated use of discipline technologies
- team members motivated by applications of state of the art technologies in areas of expertise
- higher level of sophistication leads to higher risk and complexity resulting in added difficulties which tend to reduce effectiveness (schedule slips, blown budgets, etc.)

- **Potential Interventions**

- accept added risk and complexity, plan for set-backs
- set objectives to raise required technology level and allowable risk
- develop experience/competence to reduce risk for given level of technology sophistication

# The Whole Story?



# Guidance for Selecting Interventions

- **Look for interventions that**
  - have impact throughout the system -- “work upstream”
  - are feasible and for which people are ready -- support is key!
- **Culture and mental models are much harder to change than processes and procedures**
- **Implement changes in a logical sequence**
  - don’t do everything at once
  - start small and build momentum slowly
  - be patient
- **Be sensitive to time delays**
  - delays in realization, understanding, design, implementation, impact
  - people typically underestimate delays by a factor of 3 to 5



# **Desired Characteristics of Interventions**

- **Highest Leverage Points (degree of influence throughout system)**
  - Level of Commitment
  - Turnover Rate
  - Interdisciplinary Understanding
  - Quality of Communication
- **Feasibility and Potential for Compliance**
  - Leadership, Decisiveness
  - Enhanced freedom, control, and independence
  - Streamlining, Reduction in bureaucracy, reporting, oversight, etc.
  - Opportunities for reward and advancement
- **Potential for Sustainable Change**
  - Procedures, Processes
  - Produce creative tension
  - Limit conflict with established cultural values

# **Summary of Recommended Interventions**

## **Team Sponsors and Line Management**

- ***Build level of commitment for multidisciplinary activities***
  - emphasize and strengthen benefits of team participation
  - establish challenging individual objectives/goals within a multidisciplinary context
- ***Enhance opportunities for cross-discipline understanding and appreciation***
  - establish technical objectives that encourage discipline interactions
  - accept added risk and complexity, plan for set-backs
- **Maintain and develop expertise in key areas**
  - sacrifice short term effectiveness for long term benefit of enhancing skills and expertise
  - select team members with appropriate expertise for task
  - minimize turnover

# **Summary of Recommended Interventions**

## **Team Leaders and Team Management**

- **Maintain flexible and adaptive team management processes**
  - maintain focus on priorities and mission
  - *monitor quality of communications and adapt to changing needs of information content*
  - develop and utilize benchmarks and guidelines for effective research team management methods
  - deal promptly with conflicts
- ***Exploit and/or develop skills and expertise needed for multidiscipline research***
  - accept added technical risk and complexity, plan for setbacks
  - match team members with technical requirements
  - develop key or scarce expertise for future needs
  - anticipate and prepare for turnover
  - emphasize and enhance benefits of team participation

# **Summary of Recommended Interventions**

## **Team Members**

- ***Exploit benefits of multidiscipline teaming***
  - opportunities for advancement and technical achievement
  - develop new knowledge and skills
  - establish and pursue meaningful technical challenges
  - accept technical risk and complexity to meet technical challenges
- **Influence team processes and procedures**
  - establish and maintain flexible and adaptive team processes to respond to changing priorities
  - ***establish team processes that enhance interdiscipline understanding and communication***
  - adapt to changing needs of information content
  - anticipate and deal promptly with conflicts

# Concluding Remarks

- **Results are representative of the teams that were studied**
- **Results represent significant aspects of team dynamics**
- **Likely to be representative of most multidisciplinary (and disciplinary) teams**
- **Additional assessment of consequences of proposed interventions are needed**
  - **leverage**
  - **influence and control**
  - **unintended consequences**
  - **significant delays**
  - **resource needs**